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(71) Applicant *(for all designated States except US)*: **BAE SYSTEMS PLC** [GB/GB]; Warwick House, P.O. Box 87, Farnborough Aerospace Centre, Farnborough, Hampshire GU14 6YU (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **WHITE, Nicholas, John** [GB/GB]; 14 Mulberry Avenue, Portishead, Bristol BS20 7LQ (GB).

(74) Agent: **EDIS, Ronald, Malcolm**; BAE Systems plc, Group IP Department, Lancaster House, P.O. Box 87, Farnborough Aerospace Centre, Farnborough, Hampshire GU14 6YU (GB).

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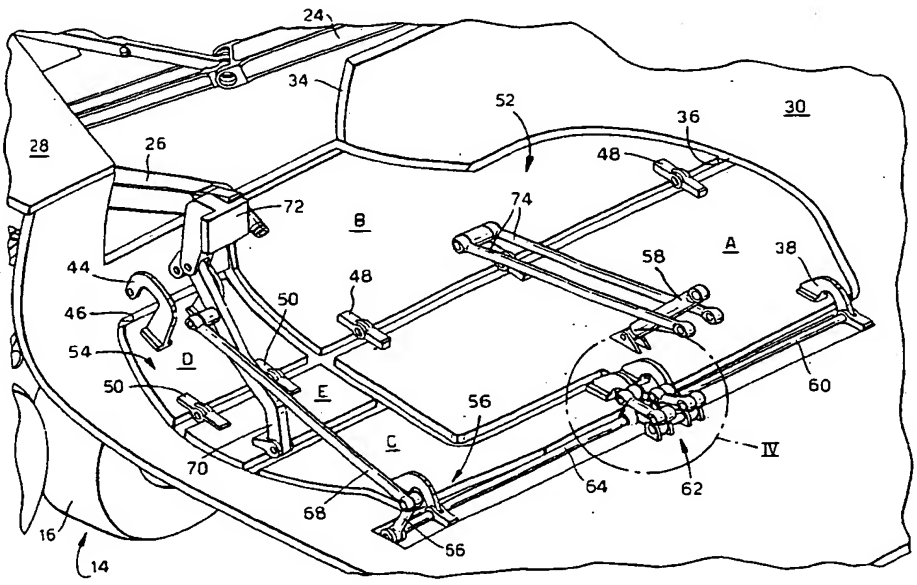
(54) Title: LANDING GEAR DOORS



(57) Abstract: A landing gear door assembly comprises first, second and third doors (52, 54, 56) which are operable to open and close an aperture (36) in an aircraft fuselage structure. A piston actuator (58) is operable to open and close the first door (52), while link means are provided between the first door (52) and the second and third doors (54, 56) to transmit motion of the first door (52) to the other doors. In a preferred embodiment the first and second doors (52, 54) are arranged to fold as they move from a closed to an open position.

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Landing Gear Doors

The present invention relates to aircraft landing doors and in particular, though not exclusively, to aircraft where multiple landing gears, when not deployed, are housed in recesses of both an aircraft's fuselage and wing.

The landing gear of commercial passenger and cargo aircraft is typically movable between a deployed position and a stored position where it is received in appropriately shaped bays. So as not to interfere with the overall aerodynamic properties of the aircraft in flight, the bays are provided with doors which, when closed, conform to the shape of the aircraft body.

According to the present invention there is provided an aircraft landing gear door assembly comprising first, second and third doors hinged for rotational movement about respective hinge axes to an aircraft structure, and actuation means operable to move the doors between open and closed positions wherein the actuation means is operable to move the first door, and the doors are linked by link means such that movement of the first door results in corresponding movement of the second and third doors.

The present invention thus provides a complex door assembly of three doors which can be opened and closed by actuation means driving only one of the doors. Synchronisation of the movement of the doors is achieved by the provision of link means between the doors.

In a preferred embodiment the first and second doors are spaced on either side of a door aperture in an aircraft structure, which may be a fuselage, wing or a combination of both, and the third door may lie adjacent the first. Preferably the respective hinge axes of the doors are substantially parallel with one another.

The link means may include a drive shaft adapted to rotate as one of the said doors pivots about its hinge axis, and a connecting rod pivotally connected to the drive shaft at a position spaced from the shaft axis; the connecting rod being arranged to move another said door. The connecting rod may be arranged so as to be movable in a direction substantially perpendicular to the axis of the drive shaft.

In a preferred embodiment the connecting rod is arranged to drive a pivotable linkage member provided between another said door and a pivot point. The pivot point may be provided on a portion of the aircraft structure. Thus it will be understood that movement of the connecting rod as a result of rotation of the drive shaft results in pivotal movement of the linkage member and hence movement of the other said door about its hinge axis.

The actuation means may comprise a linear, eg telescopic, actuator such as an hydraulic actuator. Such an actuator may be pivotally mounted between one of the said doors, for example the first door, and a point on the structure of the aircraft.

In order to aid ground clearance when open, for example, at least one of the doors may be foldable and thus arranged to adopt a folded configuration as the door moves from the closed position to the open position. In this respect, the door may comprise a first panel hinged to a structure of the aircraft, and a second panel hinged to the first panel. In a preferred embodiment the second panel is hinged to the first panel along a side opposite to the hinge side. Folding of the door may be achieved by the provision of one or more radius rods pivotally connected between the second panel and the structure of the aircraft.

In such an embodiment the pivotable linkage of the link means is pivotally connected to the second panel to effect folding of the door. Preferably the pivotable linkage is attached to the second panel at a position spaced from the hinged connection of the second panel to the first panel.

In a preferred embodiment the third door is linked to the first door, and the hinge axis of the third door is parallel to the hinge axis of the first door. Preferably the hinge axis of the third door is co-linear with the hinge axis of the first door.

The door assembly preferably includes a differential linkage to transmit differential movement between the first and third doors. The differential linkage preferably links a position on the first door spaced a first distance from the hinge axis thereof and a position on the third door spaced a second and different distance from the hinge axis thereof via an intermediate pivotal connection. The intermediate pivotal connection may include a torque shaft to take up separation between adjacent hinges on the respective doors.

In order to allow for the said differential movement of the first and third doors, for example to allow one of these doors to avoid a component of an adjacent landing gear when the door is open, the link means may comprise a drive shaft adapted to rotate as the first door rotates about its hinge axis and a bell crank arrangement, such as the differential linkage above, operable between the drive shaft and the third door. In an alternative embodiment a gear arrangement may be used in place of the bell crank arrangement to provide the required differential movement.

A or the drive shaft may extend the width of a said door, and may connect hinges thereof, whereby to transmit torque from one side of the door to the other.

The link means further preferably includes a pivotable link member, the link member being attached at one end to the door and at the other to the aircraft structure and being movable by the connecting rod. The radius rod may comprise the link member of the link means.

In order to provide a space efficient door assembly design at least one door may include a cutaway portion adapted to be filled, at least in part, by another said door, for example an adjacent door. In this way part of the space that would normally be occupied by a

single door may be arranged to be occupied by two or more doors which may open with the aforesaid differential movement so that one of the doors may move in a manner so as to avoid an obstacle. Such an obstacle may, for example, be part of an adjacent landing gear or a movable part of the aircraft structure which the door would otherwise interfere with upon opening.

An embodiment of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a perspective view, looking forward, of a port wing mounted landing gear assembly where the landing gear is deployed and the fuselage landing gear doors are closed;

Figure 2 shows a perspective view of the assembly of figure 1 where the landing gear is stowed and the fuselage landing gear doors are closed;

Figure 3 shows a view looking forward where the landing gear is stowed and the fuselage landing gear doors are open;

Figure 4 is an enlarged detail of circled portion IVof Figure 1; and

Figure 5 is a view similar to that of Figure 3 showing a landing gear door assembly with a body-mounted gear deployed under a wing gear bay.

Referring to the figures there is shown a wing-mounted aircraft landing gear assembly generally designated 10 and comprising a strut 12 carrying a wheeled bogie 14 having four wheels 16. The upper end 18 of the strut 12 is connected to the aircraft structure by a pivot 20. The assembly 10 is pivotable between a deployed position (figure 1) and a stored position (figures 2 and 3) by a piston actuator 22 provided between the strut 12 and the aircraft structure. Articulated control arms 24, 26 are provided between the strut 12 and the aircraft structure, in use, to brace and maintain the landing gear assembly 10 in the deployed position.

In the embodiment shown the landing gear assembly 10 is pivotally connected within the wing. As can be seen in figures 2 and 3, when the assembly 10 is in the stored position it is received both in a recess of the wing and a recess of the fuselage. For the

sake of simplicity in describing the invention the wing is represented by wing skin 28 and the fuselage by belly fairing 30. Figure 2 additionally shows a section of the fuselage internal structure 32.

Apertures 34, 36 are provided in the wing skin 28 and belly fairing 30 respectively to enable the landing gear 10 assembly to move between its stored and deployed positions, and the apertures 34, 36 are provided with doors.

The belly fairing aperture 36 is provided with five door panels, hereinafter referred to as panels A, B, C, D and E. First panels A and C are connected by hinges 38 and 40 to an inboard edge 42 of the belly fairing aperture 36, while first panel D is connected by hinges 44 to an outboard edge 46 of the aperture 36. Second panels B and E are connected by hinges 48 and 50 to first panels A and D respectively. It will thus be understood that first and second panels A and B define a first door 52, first and second panels D and E define a second door 54 and panel C defines a third door 56. The doors 52, 54, 56 are movable so as to open and close the belly fairing aperture 36. A further door panel F is provided on the strut 12 which in use closes wing skin aperture 34 when the landing gear assembly 10 is in the stowed position.

Opening and closing of the doors 52, 54, 56 is effected by a piston actuator 58 provided between panel A and the aircraft structure. The piston actuator is hydraulically operated. Synchronisation of the doors 52, 54, 56 and panels A, B, C, D and E during opening and closing thereof is achieved by the provision of the following arrangement. A first drive shaft 60 is connected to the hinges 38 of panel A such that pivotal movement of panel A about said hinges 38 results in rotation of the first drive shaft 60 about its axis. A pair of radius rods 74 is pivotally connected between panel B and the aircraft structure.

The first drive shaft 60 is connected via a differential movement arrangement of bell cranks 62 to panel C and a second drive shaft 64. Rotation of the first drive shaft 60

results in pivotal movement of panel C about its hinges 40 and rotation of the second drive shaft 64.

The end of the second drive shaft 64 remote from the bell crank arrangement 62 carries an arm 66 which in turn is pivotally connected to a connecting rod 68. The connecting rod 68 extends between the arm 66 and a pivotable link member in the form of a crank arm 70. The crank arm 70 is pivotally connected between a bracket 72 on the aircraft structure 32 and an edge of second panel E of door 54.

Opening of the doors 52, 54 and 56 is achieved by extending the piston actuator 58. Dealing firstly with the first door 52, composed of panels A and B, extension of the piston actuator 58 causes downward pivotal movement of panel A. As first panel A moves down, the radius rods 74 cause second panel B to fold towards panel A. Continued extension of the piston actuator 58 results in the first door 52 and panels A and B being moved to the fully open position shown in figure 3, with the panels A and B folded together with their inner surfaces facing each other.

As the piston actuator 58 extends to cause first panel A to pivot about its hinges 38, the pivotal movement occasions rotational movement of the first drive shaft 60. Via the bell crank arrangement 62, the aforementioned rotation of the first drive shaft 60 is utilised to pivot panel C by a lesser amount about its hinges 40. Thus, as the first door 52 opens so does the third door 56, but by the lesser amount. The fully open position of the third door 56 can be seen in figure 3. In an alternative embodiment the bell crank arrangement 62 may be replaced by an arrangement of gears to transmit the differential motion to panel C.

The bell crank arrangement 62 also translates the rotational motion of the first drive shaft 60 into rotation of the second drive shaft 64 and ultimately the opening and closing of the second door 54. As the second drive shaft 64 rotates, it moves the arm 66 and hence causes the crank arm 70 to pivot about the bracket 72. This pivotal movement of the crank arm 70 causes first panel D to rotate about hinges 46 and second

panel E to fold towards panel D. Once fully opened, the second door 54 adopts the position shown in figure 3. Doors 52, 54 and 56 are now clear of wheels 16 to allow gear 10 to be lowered into the deployed position.

While the above described operation of the doors 52, 54 and 56 relies upon the piston actuator 58 to achieve opening thereof they can also fall open under their own weight, for example, if the hydraulic supply to piston actuator 58 fails. This ensures that in the event of such a failure of the piston actuator 58 the doors can be opened to allow the landing gear assembly 10 to be lowered. The doors 52, 54 and 56 can also be caused to open by the action of the landing gear assembly 10 bearing against them. This envisages a scenario where the piston actuation 58 may be jammed and hence holding the doors 52, 54 and 56 closed. First panels A and/or C may be provided with guides or plattens engageable by the wheels 16 of the landing gear assembly 10 in such a situation, and the piston actuator 58 may be connected to panel A and/or the aircraft structure 32 by suitable release means such as shear pins.

Referring to Figure 4, adjacent hinges 38, 40 of door panels A and C can be more clearly seen and can be seen to be connected to respective drive shafts 60 and 64. The bell crank type arrangement 62 comprises two arms 80, 82 of different length to provide the differential movement between shafts 60 and 64, two connecting links 84, 86 and an intermediate pivotal connection in the form of a short drive shaft 88 having transfer arms 90, 92 affixed to either end thereof. The arrangement is such that angular rotation of shaft 60 will always be greater than that of shaft 64, owing to arm 80 being shorter than arm 82 and thus spacing pivot point 94 a lesser distance from the common axis of shafts 60, 64 than pivot point 96 on arm 82.

In this way door 56, positioned immediately in front of tyre 98 (see Figure 5) of body landing gear 100, will open sufficiently to allow clearance of wheels 16 of gear 10, but insufficiently to foul tyre 98, when deployed. The deployment path 102 of wheels 16 of gear 10 is shown. This passes just in front of the deployed position of body gear 100.

Claims

1. An aircraft landing gear door assembly comprising first, second and third doors hinged for rotational movement about respective hinge axes to an aircraft structure, and actuation means operable to move the doors between open and closed positions wherein the actuation means is operable to move the first door, and the doors are linked by link means such that movement of the first door results in corresponding movement of the second and third doors.

2. A door assembly as in claim 1 wherein the first and second doors are spaced on opposite sides of a door aperture in the aircraft structure and the third door lies adjacent the first door.

3. A door assembly as in claim 2 in which the link means includes a differential linkage to transmit differential movement between the first and third doors.

4. A door assembly as in claim 3 in which the differential linkage links a position on the first door spaced a first distance from the hinge axis thereof and a position on the third door spaced a second and different distance from the hinge axis thereof via an intermediate pivotal connection.

5. A door assembly as in claim 4 in which the intermediate pivotal connection includes a torque shaft to take up separation between adjacent hinges on the respective doors.

6. A door assembly as in any preceding claim in which the link means includes a drive shaft adapted to transmit the said rotational movement as the first door rotates about its hinge axis and a connecting rod connected to the drive shaft at a position spaced from the shaft axis, the connecting rod being arranged to move another said door.

7. A door assembly as in claim 6 in which a said drive shaft extends the width of a said door, whereby to transmit torque from one side of the door to the other.

8. A door assembly as in any preceding claim in which the link means further includes a pivotable link member, the link member being attached at one end to the door and at the other to the aircraft structure and being movable by the connecting rod.

9. A door assembly as in any preceding claim in which the actuation means comprises a linear actuator pivotally mounted between the first door and the aircraft structure.

10. A door assembly as in any preceding claim in which at least one said door is foldable and thus arranged to adopt a folded configuration when moving from the closed position to the open position.

11. A door assembly as in claim 10 in which the foldable door includes a first panel hinged to the aircraft structure, a second panel hinged to the first panel and a radius rod pivotally connected between the second panel and the aircraft structure.

12. A door assembly as in claim 11, when dependent on claim 8, in which the radius rod comprises the link member of the link means.

13. A door assembly as in any preceding claim in which the hinge axis of the third door is co-linear with the hinge axis of the first door.

14. A door assembly as in claim 3 in which the link means includes a drive shaft adapted to rotate as the first door rotates about its hinge axis and a gear arrangement acting between the drive shaft and the third door.

Fig.1.

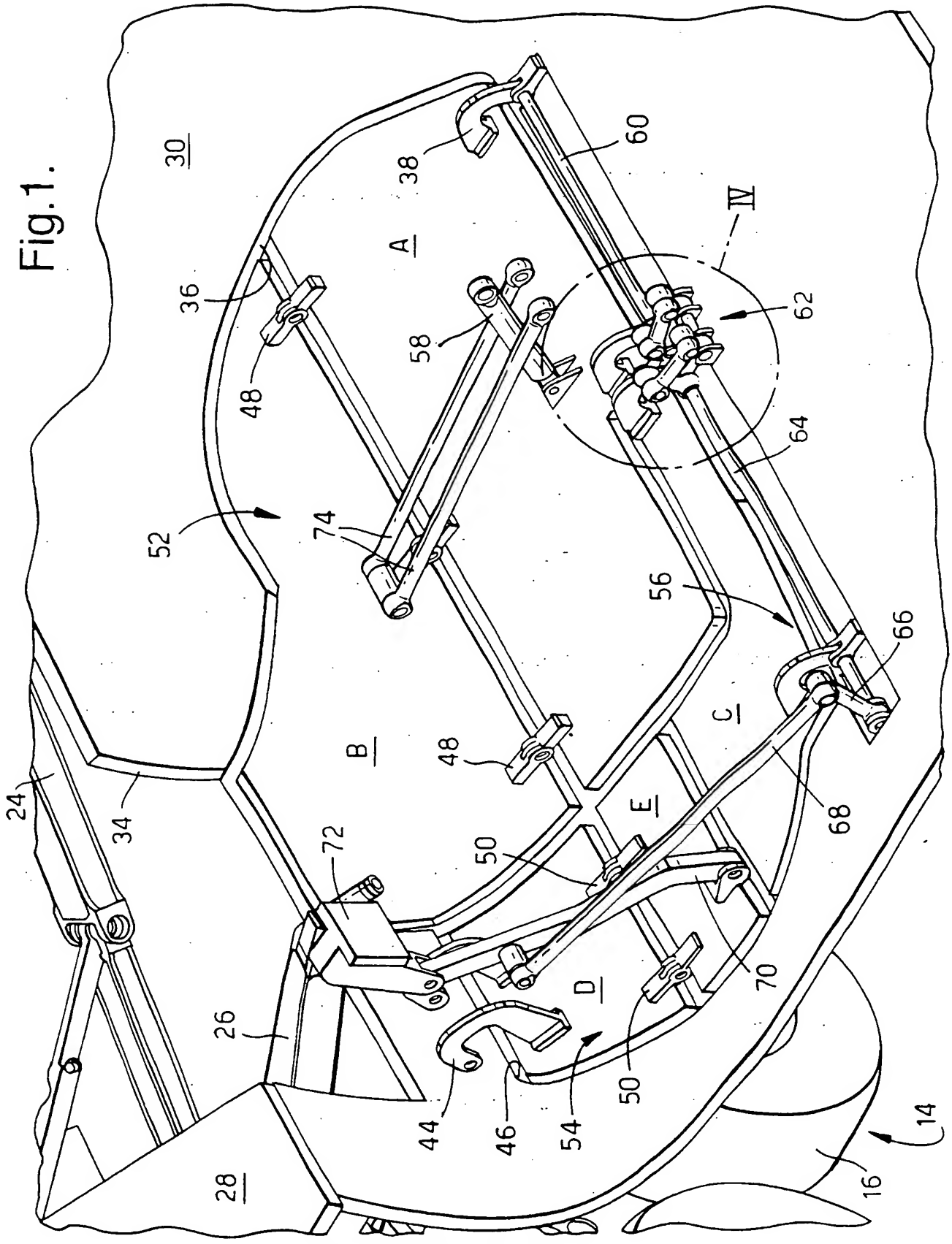
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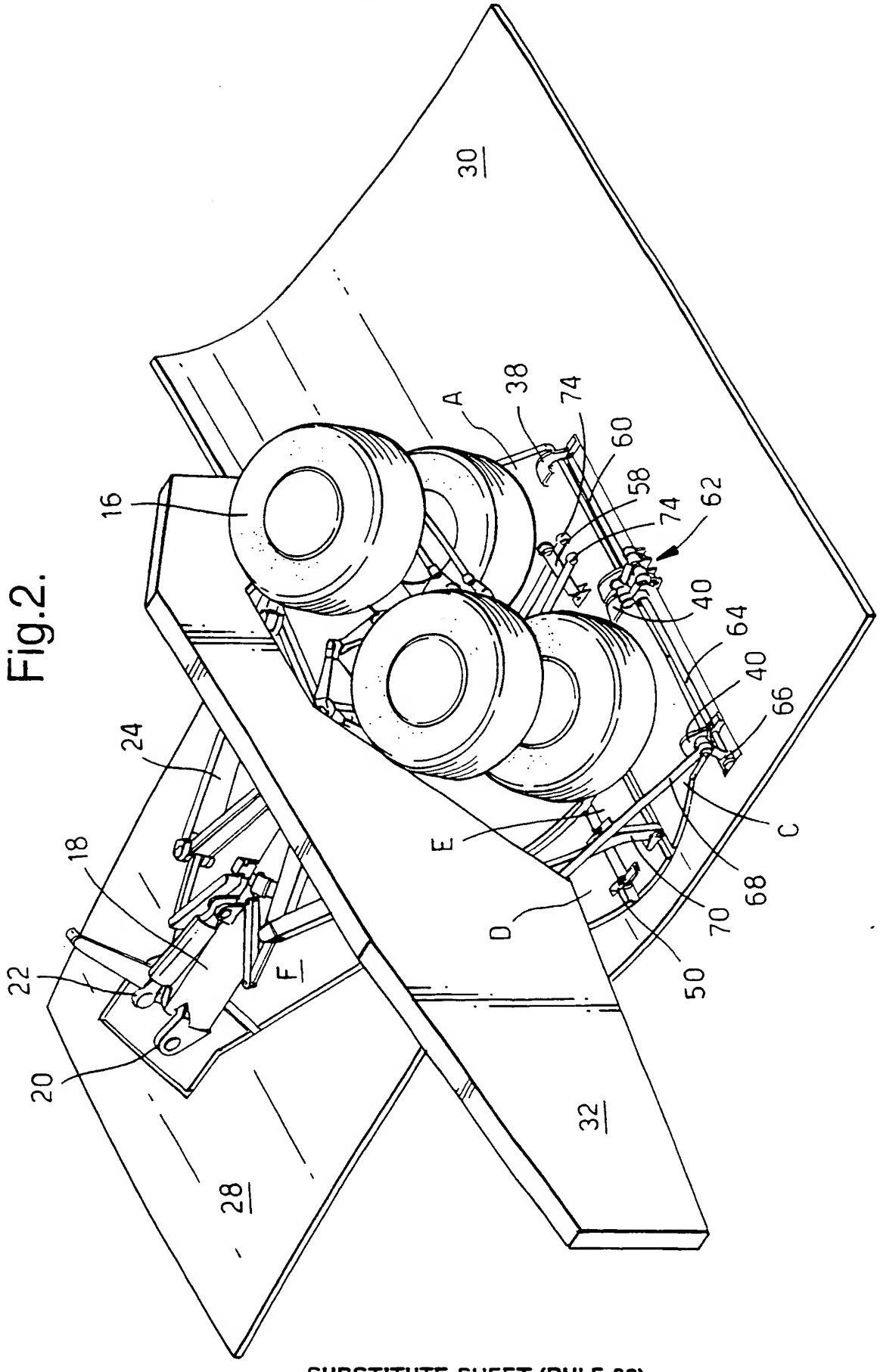
Fig.2.



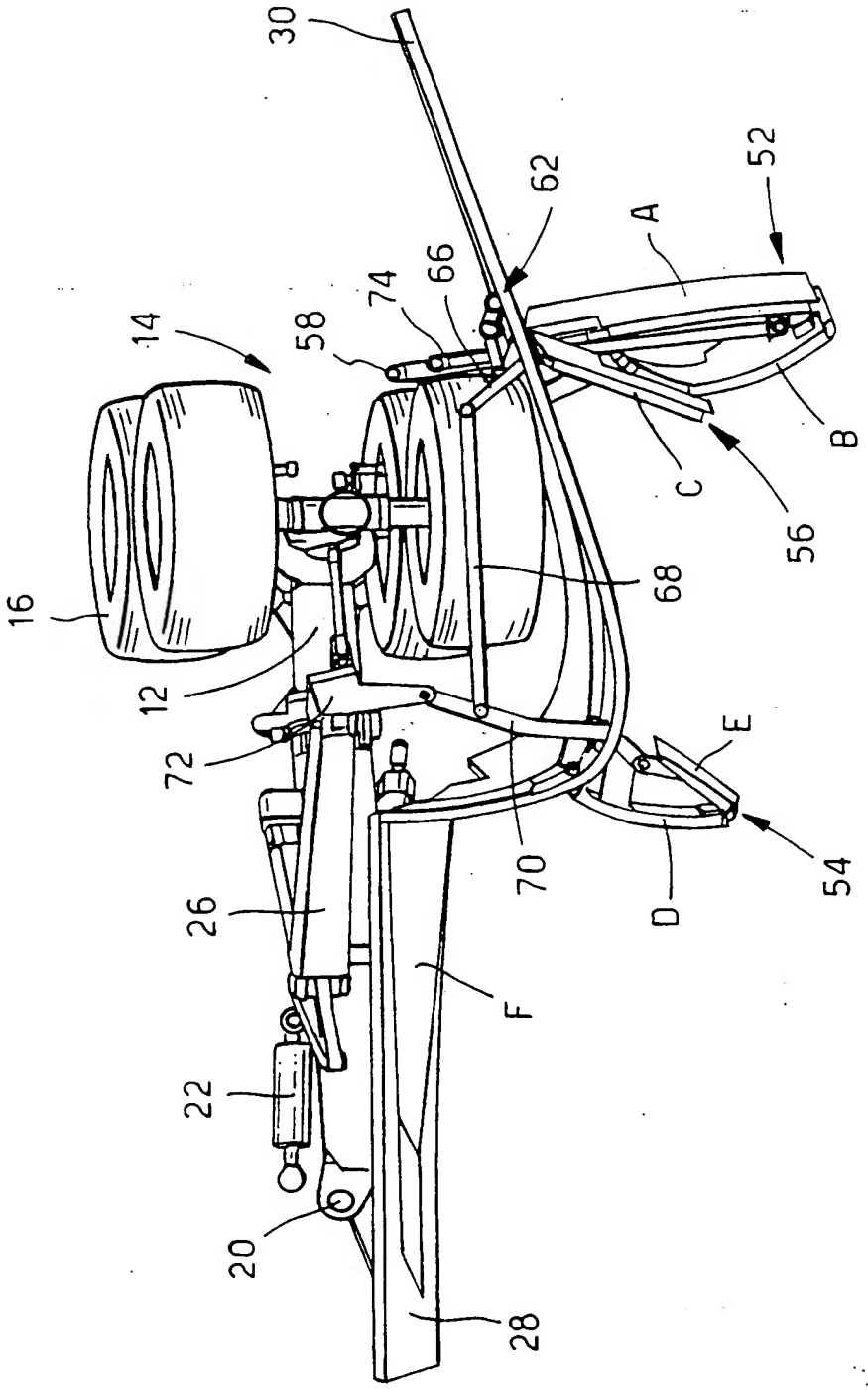


Fig.3.

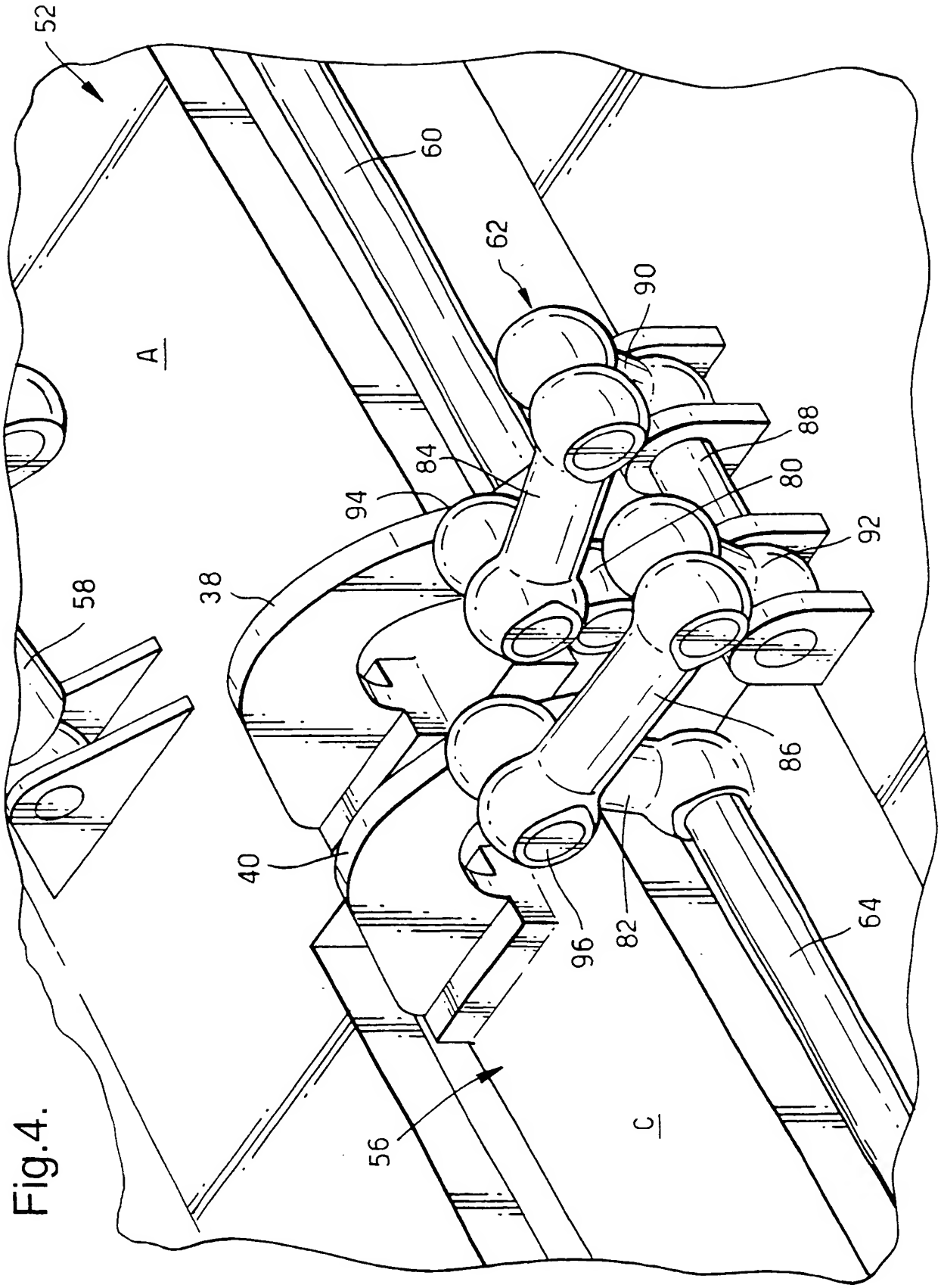


Fig.4.

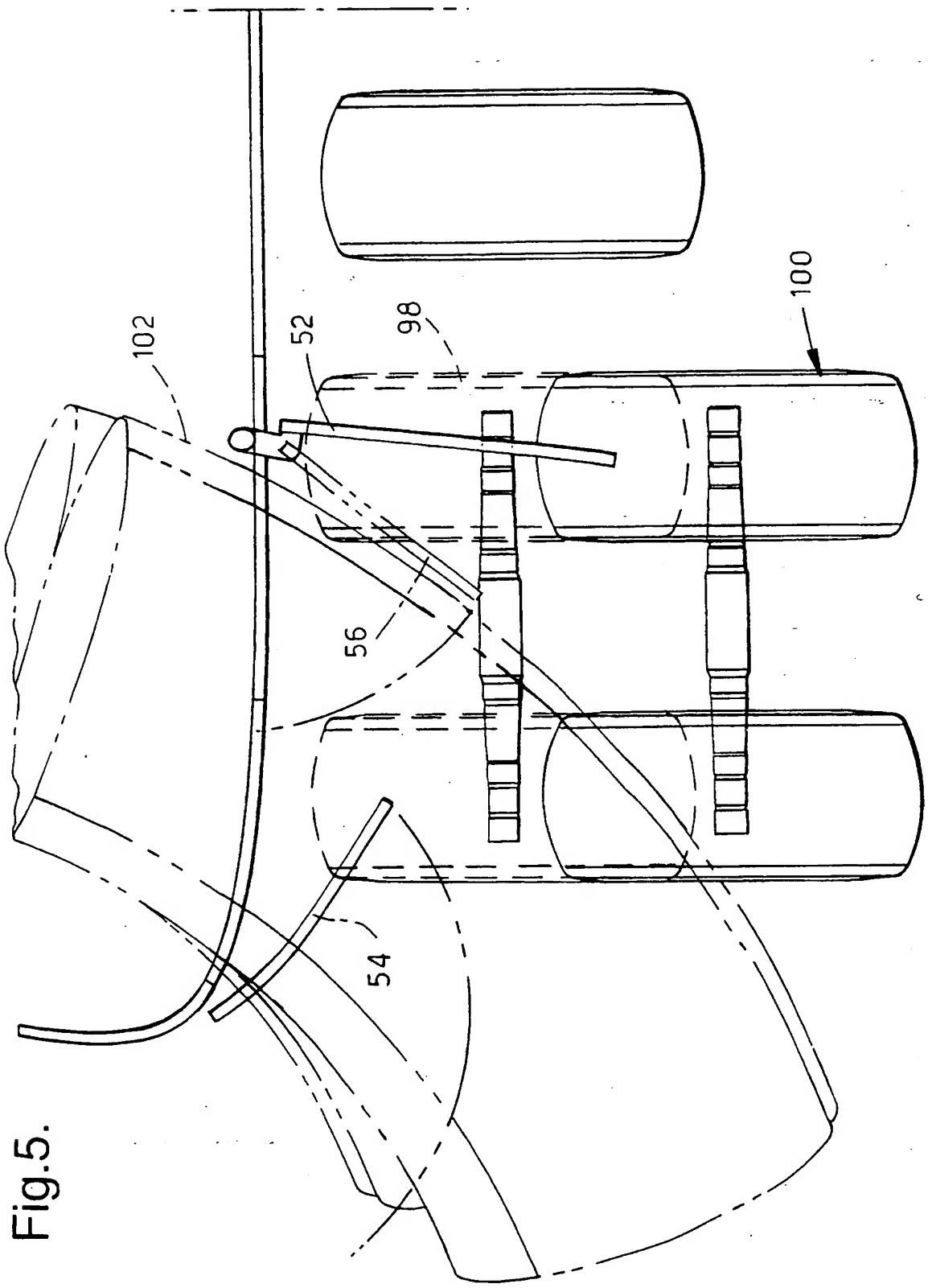


Fig.5.

INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/GB 01/00426

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B64C25/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B64C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2 406 710 A (RIGGLES WILLIAM M JR ET AL) 27 August 1946 (1946-08-27) the whole document	1-3,6
A	---	4,5,7-14
X	US 4 412 665 A (KRAMER LOUIS T ET AL) 1 November 1983 (1983-11-01) column 4, line 46 -column 5, line 25 figure 3	1-3
A	---	4-14
A	GB 713 258 A (ROY ROBERT) 11 August 1954 (1954-08-11) the whole document	1-14

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 March 2001	17/04/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Pedersen, K

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PCT/GB[illegible]/00426

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 739 351 A (MESSIER DOWTY SAS) 4 April 1997 (1997-04-04) page 10, line 7 -page 11, line 27 figure 2 ---	10,11
A	DE 12 84 851 B (VEREINIGTE FLUGTECHNISCHE WERKE) 5 December 1968 (1968-12-05) the whole document -----	1-14

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Internat[illegible]al Application No
PCT/GB 01/00426

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2406710 A	27-08-1946	NONE	
US 4412665 A	01-11-1983	NONE	
GB 713258 A		NONE	
FR 2739351 A	04-04-1997	NONE	
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